Layered Piezo–Thermo–Tribo Energy Harvesting System

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📄 Abstract

This invention describes a multi-layered energy harvesting system that integrates **piezoelectric**, **thermoelectric**, and **triboelectric** modalities into a unified architecture. Designed for modular deployment across urban infrastructure, wearables, and autonomous devices, the system captures mechanical stress, heat differentials, and frictional motion to generate clean, decentralized power. The layered configuration enables synergistic energy conversion, adaptive routing, and scalable output for off-grid and regenerative applications.

🧱 Layer Architecture

Layer	Function	Energy Source
Top Layer	Triboelectric	Friction from wind, rain, human contact
Middle Layer	Piezoelectric	Mechanical stress, vibration, motion
Base Layer	Thermoelectric	Heat differentials from ambient environment

Synergy:

- Triboelectric surges prime piezoelectric activation
- Piezoelectric strain amplifies thermal gradients
- Thermoelectric flow stabilizes and stores residual energy

⚙️ System Enhancements

- **MEMS-Based Switching**: Micro-actuators reroute energy flow based on environmental input
- **Phase-Change Materials**: Embedded in the thermoelectric layer to optimize heat absorption and release
- **Modular Expansion Ports**: Snap-fit or magnetic connectors allow chaining multiple units
- **Hybrid Storage**: Combines supercapacitors (for fast surges) and solid-state batteries (for long-term storage)

- **AI Microcontroller**: Maps real-time exergy and dynamically prioritizes energy routing

⚙️ Exergy Cascade Logic

- **Domino Activation**: Environmental triggers sequentially activate layers
- **Self-Tuning Feedback**: Sensors monitor vibration, temperature, and friction to optimize harvesting
- **Adaptive Layer Reconfiguration**: Layers shift or reroute based on input conditions

🌍 Use Cases

Application	Description
Smart Pavement	Harvests foot traffic and ambient heat
Wearables	Converts body motion and temperature into power
Urban Furniture	Powers kiosks, benches, and lighting
Autonomous Drones	Extends flight time using motion and thermal harvesting
Industrial Machinery	Captures vibration and heat for predictive maintenance

Claims

1. A multi-layered energy harvesting device comprising triboelectric, piezoelectric, and thermoelectric modules arranged to trigger sequential energy conversion.
2. The system of claim 1, wherein environmental feedback activates a domino-effect energy cascade.
3. The system of claim 1, further comprising MEMS-based switching for dynamic energy routing.
4. The system of claim 1, wherein hybrid energy storage includes supercapacitors and solid-state batteries.
5. A method for autonomous energy harvesting using embedded sensors to inform routing logic and layer prioritization.

📜 Statement of Intent

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□ Attribution

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